PATENT ABSTRACTS OF JAPAN

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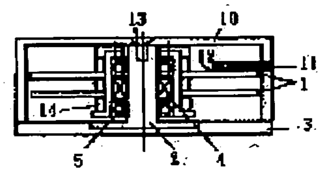
(54) DISK FLUTTER DAMPING DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To damp disk flutter caused by an exciting force of air by setting up a smooth fixed wall surface nearby parallel to a disk surface satisfactorily getting near the disk surface in a partial annular surface region expanding in the radial direction and circumferential direction of the one-side surface of the disk surface and forming a damping effect based on the principle of squeeze air bearing in the gap between two surfaces thereof.
SOLUTION: A squeeze air bearing plate 11, whose surface facing a disk surface is smoothly worked, is fixed to the side surface casing of a disk device in the peripheral part nearly parallel to the disk surface. The gap 12 between the squeeze air bearing plate 11 and the uppermost surface of the disk 1 is satisfactorily lessened, and the value is specified to nearly 0.3 mm or less. In such a manner, the squeeze damping force of the air film exerting on the disk surface is enlarged into largeness enough to damp flutter toy lessening the gap 12. Moreover, the whole disk surface is not covered, but a part of the disk surface is covered by the bearing surface forming the small gap.



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CLAIMS

[Claim(s)]
[Claim 1] The disk flutter damping device characterized by having made the squeeze pneumatic-bearing board which spread in a circumferencial direction and radial at one side of the best side, the lowest side, the both disk side, or all disk sides, and which has an annular smooth side partially counter a disk side in a crevice 0.3mm or less in a disk spindle mechanism with the disk of one sheet or two or more sheets, and carrying out installation fixation.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001] A [technical field to which invention belongs] this invention relates to the equipment which damps disk flutter vibration by which air excitation is carried out with a raise in the rotational speed of magnetic disk memory or an optical disk memory.
[0002] As for [Prior-art] magnetic disk memory, densification and high-speed-ization are always demanded. Especially disk rotational speed exceeds 10000rpm, and the magnetic disk unit for high-end will require the more and more high recording density-ization under the further high rotational-speed conditions from now on. Although to improve especially track density is demanded strongly, vibration of the disk which an eddy is formed in the airstream between disk boards, or the air of the disk circumference is confused, excites the natural frequency of a disk along with increase of disk rotational speed, and is called disk flutter arises, and this causes a truck gap. Although there are various kinds in vibration of a disk spindle, the locking imbalanced mode in which a disk and a shaft incline and vibrate by the inphase or the antiphase also especially in it serves as a key factor of a truck gap. There is also nonrotation synchronous vibration produced from anti-friction bearing among the vibration of the disk leading to a truck gap. Although the liquid bearing is going to be used in order to remove this, if the disk flutter excited in aerodynamic force is not oppressed even if a liquid bearing is used, the advantage of a liquid bearing cannot be employed efficiently. For this reason, it was a big technical problem for damping and removing a disk flutter developing a highly efficient magnetic disk unit in recent years.
[0003] In order to remove the eddy of the air between disk sides and to abolish disorder of the air of the disk periphery circumference as this solution, a hole is made in the spacer ring of the clamp mechanism of the center of a disk, and the structure of making air blowing off from a center section using the centrifugal force of air at the time of rotation is proposed. Moreover, the structure which sealing covering of the disk circumference is made to approach the disk side, and prevents a turbulent flow was proposed. Furthermore, in order to prevent the eddy of the shape of a cell produced between disk boards, and the flutter of the head suspension by this, the method of inserting the partial board called spoiler locally between disk layers is also proposed. However, these were for preventing generating of the turbulent flow and vortex which do not oppress vibration of the De Dis board by attenuation, but are produced between disk layers. Moreover, these methods did not have the effect which can not necessarily oppress a flutter over a latus frequency domain. Although the proposal which uses the large disk board made from a ceramic of attenuation was also proposed on the other hand, it became expensive, and change of IE was also required and its demerit was large.
[0004] On the other hand, as shown in drawing 1 , I.Y.Shen and others approaches the best side of a disk spindle, carries out a support setup of the annular disk 6 through the viscoelasticity material 8 from the arm top cover 7 of equipment, and has proposed the flutter damping mechanism which absorbs the vibrational energy of a disk spindle using the principle of a dynamic vibration reducer in recent years. The crevice between an annular disk and the disk best side forms dynamic pressure pneumatic bearing, and is made to be transmitted to the mass which aligned vibration of a disk spindle using the spring effect by the compressibility of air by about 0.635mm. Although it is shown that the attenuation to which it damps produces the annular disk disk flutter which they approached, the dynamic-vibration-reducer structure of drawing 1 is proposed only now noting that there are few effects. Since a squeeze damping effect is seldom produced when the crevice between the smooth sides which counter a disk side is too large like [in this case] and a disk vibration amplitude is 1 or less % of a crevice, the exciting force of disk vibration is transmitted to an annular disk using the spring effect produced as a hydrodynamic bearing, and the method of attenuating the vibration by viscoelasticity material becomes effective. By this dynamic-vibration-reducer form damping mechanism, attenuation of the flutter of a disk is the relation which absorbs an annular disk by the viscoelasticity material which supports about vibration transmitted to the annular disk instead of an air film between an annular disk and a disk. However, an alignment design and the design of the damping effect of support attenuation material were not easy for this kind of damping mechanism, and it had the fault which moreover becomes complicated [a mechanism].
[0005] A [Object of the Invention] this invention is damping the disk flutter produced by the exciting force of the air acting as high-speed-izing of a magnetic disk, and the greatest obstacle of a raise in track density as mentioned above. it is not based on the principle using the means which makes the size of the disturbance force of conventional air small especially or the spring effect of pneumatic bearing, and the damping force of external-damping material of a dynamic vibration reducer, but vibration of a flutter is damped by the easier means -- they are things
[0006] The subring-like side field which spread in radial and the circumferencial direction of one side of a disk side is made to approach a disk side enough, and the disk flutter damping device of a [The-means-for-solving-a-technical-problem] this invention installs a smooth fixed wall surface almost parallel to a disk side in it, is characterized by making the damping effect based on a squeeze pneumatic-bearing principle form in the crevice between a disk side and a stationary-plate side, and explains it in detail using a drawing below.
[0007] [Gestalt of implementation of invention] drawing 2 and drawing 3 are drawings showing the fundamental operation gestalt of this invention. A view 2 is a cross section of basic structure, and, for a disk and 2, as for a substrate and 4, a main fixed shaft and 3 are [1 / a motor and 5] anti-friction bearings. The squeeze pneumatic-bearing board with which 11 makes the center of this invention, and 12 are the crevices between a disk board and a squeeze pneumatic-bearing board. Moreover, the spacer ring for ****ing and 14 fixing two or more disk boards in a fixed crevice with which 10 combines upper surface covering and 13 combines upper surface covering and a main fixed shaft, and 15 are side cases, and are being fixed to the substrate 3. Drawing 3 is the external view showing the feature of the configuration of the squeeze bearing board of drawing 2 , and is drawing which omitted the upper surface covering 10, a substrate 3, the side case 15, etc. of drawing 2 . 16 is the record reproducing head and

17 is a head positioning mechanism.
[0008] The 1st feature of the squeeze pneumatic-bearing board 11 is that the field which counters a disk side is processed flat and smooth, and is being mostly fixed to parallel by the side case 15 of a disk unit by the periphery with the disk side. The 2nd feature has enough the small crevice 12 between the squeeze pneumatic-bearing board 11 and the best side of a disk 1, and it is specifically about 0.3mm or less. especially this point is an important point of producing a different effect from the conventional technology shown in drawing 1 , and the squeeze damping force of the air film which acts on a disk side makes it sufficient size for making a flutter damp by making it small in this way -- things are made The 3rd feature of the squeeze pneumatic-bearing board 11 is that the bearing surface which forms a small crevice covers not the whole disk side but a part of disk side. Although this covering field changes by other design conditions of a disk unit, in the case of a 3.5 inch disk, usually, the range of it is theta= 60 degrees - 270 degrees, and it is [a circumferencial direction] in radial from a periphery side at the range of lx=10mm to 20mm. As for the radial length, generally depending on the path of a disk, about [of an effective radius / 1/2 or less] is desirable. This range is because the rate of increase of a damping effect decreases by the inner circumference side since a flutter amplitude also becomes small, even if it enlarges not much at a radial inner circumference side, although the larger one has a large effect.
[0009] With the squeeze pneumatic-bearing board 11 with the physical relationship of the above configurations and a disk side, by vibration of a disk, the air in a crevice goes in and out from a crevice by vibration of a disk, and the viscous-drag force which is proportional to the velocity of vibration of a disk according to the viscosity of air acts on a disk. flutter vibration which has a component from 500Hz to severalKHz although this viscous-drag force has the frequency characteristic -- or less at least 1 / 2 -- decreasing -- the crevice between a bearing board and a disk board -- sufficient thing made small is important Although the crevice for acquiring this effective damping effect may be so large that a bearing surface product is large, in the case of the diameter disk of 3.5 inch, you have to make it at least 0.3mm or less, for example. Moreover, it is necessary to make it still smaller as a bearing surface product becomes small. The fundamental damping effect of the squeeze pneumatic-bearing board obtained by an experiment and analysis below is explained in detail.
[0010] Drawing 4 is as a result of [of the frequency spectrum of the case where there is no stationary plate, and the disk vibration when attaching a squeeze pneumatic-bearing board] measurement, when rotating the disk of one sheet by 9600rpm. Although vibration of a disk is the result of measuring near the lower stream of a river of a squeeze pneumatic-bearing board, its near upstream of a bearing board is also almost equal. The squeeze pneumatic-bearing board is installed so that a minute crevice parallel to a disk side may be maintained in the range with a radial width-of-face lx=15mm and an angle [of a circumferencial direction] of theta= 90 degrees, and it is the experimental result of the flutter damping effect when changing the crevice between bearing boards in h= 50-100 micrometers. The peak of the spectrum in this drawing consists of a thing of the integral multiple of rotational speed, and the other component. Although an amplitude does not change with these squeeze pneumatic-bearing boards since the former is based on the wave of a disk side, it does not become the cause of a truck gap. Only the latter is the disk oscillating component which is the disk flutter excited at random and serves as a key factor of a truck gap with air. Although the various natural frequencies of a disk are excited by the disturbance force of an airstream in the 0.5kHz - 2.5kHz field when there is no squeeze pneumatic-bearing board 11 as shown in this drawing, in the case of h= 50 micrometers of crevices, all flutter components are damped nearly completely. Although the damping effect will become weaker if it becomes about h= 100 micrometers of crevices, if an about 500Hz component with the smallest frequency is removed, the vibration amplitude will be reduced to 10 by about 1/. It is clear from these drawings that the disk flutter damping device's using the squeeze pneumatic-bearing effect of this invention there is a remarkable effect. As for vibration of the disk which attached this damping device, it is most effective that avoid the head positioning mechanism 17 near the squeeze pneumatic-bearing board 11, and it installs in the position near the record reproducing head 16 as shown in drawing 3 on the occasion of application to an actual disk unit since vibration is oppressed most. However, what is necessary is for other design conditions just to determine the installation of a bearing board, since the disk flutter of the angular position which is most separated from the squeeze pneumatic-bearing board 11 is also damped enough, considering the property of the oscillation mode.
[0011] Drawing 5 (a) and drawing 5 (b) consider the length of a bearing board as theta= 90 degrees with the angle of circumference, and are the theoretical analysis result of squeeze damping-force F/alpha=Cs omega [in / the rectangle squeeze bearing in lx=15mm and 10mm / for the width of face] per unit width of face (for a disk vibration amplitude and Cs, a damping coefficient and omega are / F / a damping force and alpha / angular frequency). A parameter is the crevice h between squeeze air film thickness, i.e., a disk side, and a bearing board. It is the frequency domain which becomes fixed [the field where damping-force Csomega increases-like proportionally in frequency / a damping coefficient], and an air film mainly becomes dominant [a damping force] at this time. However, in the field in which a crevice becomes small and frequency becomes high like [in h= 40-50 micrometers of drawing 5 (a)], a damping force is saturated, and for the compressibility of air, the damping effect of an air film decreases and becomes dominant [the effect of a spring] instead. It is characterized by this invention using the field where a damping force is proportional to frequency, and therefore, even if a disk, a bearing board, and a crevice are too small not much, an effect cannot be demonstrated. About h= 40 micrometers of crevices are the the best for reducing disk flutter vibration of several kHz or less from this drawing in the case of lx=15mm. If width of face becomes large, the crevice where this damping effect serves as the maximum will be made greatly-like proportionally. If it is difficult to set a crevice to 50 micrometers or less from the relation of assembly ****** in fact and a crevice is made small, driving torque will become large for the viscous force of an air film. According to the experiment using the veneer disk, the amount of increases of the current of the drive motor when setting up lx=15mm and a theta= 180-degree bearing board with the largest area in 40 micrometers of crevices was about 10%. However, in an actual magnetic disk unit, since it is surrounded by covering and the side attachment wall, it is expected that increase of driving torque with a bearing board becomes larger. Therefore, on the occasion of utilization, a crevice is determined in consideration of the trade-off with the damping effect of flutter vibration, and driving torque increase, and assembly precision.
[0012] In order to make a damping effect into the maximum under the area fixed condition of a squeeze pneumatic-bearing board, about any [the width of face lx of the bearing surface, and] of the angle of circumference theta should be made large, it can guess from drawing 5 (a) and 5 (b). If the frequency of vibration observes by 2kHz in these drawings in the case of h= 50 micrometers of crevices, damping-force F/alpha=Cs omega per unit amplitude is m in it it F/alpha =3N/m and 1N /at the time of lx=15mm and 10mm. That is, the damping force is 3 times if width of face of the bearing surface is enlarged 1.5 times. In the case of a band-like squeeze pneumatic-bearing side, this reason is that a damping force is proportional to the product of squeeze number sigma=12microomegalx2/h2 (mu is a viscosity coefficient of air) and bearing surface product lxtheta. That is, a damping force is proportional to the cube of the bearing width of face lx, and proportional to the angle of circumference theta. Therefore, in order to heighten the damping effect of a disk flutter, it is effective rather than the direction which enlarged width of face lx

with the narrower bearing surface enlarges angle of circumference length theta. However, since the amplitude of flutter vibration of a disk becomes small in the field where a radius position is small, even if it enlarges width of face lx from the periphery of the bearing surface not much, increase of the damping effect cannot be desired. The suitable bearing width of face lx will be to about 20mm, since the inradius which fixes a disk in the case of a 3.5 inch disk unit is about 15mm and an effective disk side radius is about 30mm. general — fixation of a disk — about [of the effective radius of a hub to an outside] 1/2 is suitable
[0013] the component with high frequency of the experimental result of drawing 4 to the flutter damping effect is larger, and the circumference component of back which is the minimum primary locking imbalance mode this [whose] it is the mode of the about 0.5kHz node circle 0 of the following frequency and the node diameter 1, and is one of the factors of a truck gap has the smallest damping effect then, the minimum which is the hardest to be damped — drawing 6 showed the ratio (amplitude reduction ratio) with an amplitude in case there is no squeeze pneumatic-bearing board of a vibration amplitude in case there is a bearing board about lx=10mm, 15mm, and the angle of circumference in bearing width of face about four kinds of squeeze pneumatic-bearing boards (theta= 90 degrees and 180 degrees) which it changed at a time two levels, respectively paying attention to the following flutter oscillating component as a function of a crevice Drawing 6 is the case where rotational speed is 9600rpm, and each parameter is the difference in the size of the bearing surface. I am doing as the property of the damping effect which the damping effect is [to increase width of face lx 1.5 times] larger, and this showed by drawing 5 (a) and 5 (b) one rather than that these drawings show makes the angle of circumference theta double precision although the damping effect generally has the large one where a bearing surface product is larger especially Also in h= 100 micrometers of crevices, at lx=15mm and theta= 180 degrees, the flutter is reduced to one fifth by about 1/10, lx=10mm, and at least theta= 90 degrees, and the remarkable damping effect of the squeeze pneumatic-bearing board of this invention is clear from this drawing. if the crevice between a disk and a bearing plate surface is enlarged — the damping effect — a crevice — almost — in inverse proportion — decreasing — **** — therefore — a crevice — about h= 0.2mm — even when — a flutter vibration amplitude can be damped about to 1/5 by choosing a bearing surface product comparatively greatly Although not shown in this drawing, in the case of lx=15mm with the largest area used for the experiment, and the theta= 180-degree bearing board, the amplitude reduction ratio was 0.78 at the time of 0.58 and h= 0.37mm at the time of h= 0.3mm. For making a flutter vibration amplitude small [to one half] at least after this, even when a bearing surface product is comparatively large, a crevice needs to set to 0.3mm or less, and if driving torque conditions allow, generally it will be thought that the range of bearing clearance of 0.1mm - 0.2mm is desirable.
[0014] Disk flutter vibration damps and a different new effect from the former uses by the disk flutter damping device which was described above and which consists of a squeeze pneumatic-bearing board of this invention like easing disorder of the air between disk boards like the conventional stabilizer, not reducing exciting force, and not depending it on a dynamic vibration reducer, either, and making a disk side carry out direct action of the damping force of a squeeze air film. Thickness h of the air film of drawing 6 to squeeze pneumatic bearing needs to be 0.3mm or less to acquire the damping effect from which a flutter amplitude becomes 1/2 or less. Moreover, if the crevice of the size of a squeeze pneumatic-bearing side is 0.1mm and width of face has about 60 degrees or more of angle of circumferences again that there should just be 10mm or more from a periphery side, as for an amplitude reduction ratio, 1/3 or less will be obtained. on the other hand, since the bearing surface is also made not much large to radial and the rate of increase of the effect decreases, the width of face of the bearing surface has the range suitable for the angle of circumference of 90 to 180 degrees at about [of the effective radius of a disk] 1/2 However, in order that these values might decrease flutter vibration enough, the recommended value of the subring-like bearing surface size for producing a damping force was only shown, and this invention specifies neither a strict bearing surface configuration nor its fine size. For example, the structure shown in drawing 7 is not a strict subring-like side, and a part of edge by the side of the inradius of the upstream of a squeeze pneumatic-bearing board or a downstream is removed, and it forms the smooth inclined plane 18 so that the airstream caused with a disk may not be disturbed. Even in this case, it is necessary to set a crevice to 0.3mm or less as conditions for generating a squeeze damping effect effectively.
[0015] Although the disk flutter damping device using the damping effect of drawing 2 and the squeeze pneumatic-bearing board shown in 3 and 7 is an example in case there are two disk boards, one sheet or at least three disk boards or more can apply it. The flutter which generally serves as a key factor of a truck gap is the oscillation mode to which the shank of all the disk boards called locking imbalanced mode and center sections exercises for an inphase or an antiphase, and this vibration can be damped by making a damping force act on the topmost disk of one sheet.
[0016] The flutter damping device of a [example of invention] this invention can consider some of other examples. Drawing 8 is the case where the squeeze pneumatic-bearing board 11 is installed only in the undersurface of disk 1e of the bottom of disk of two or more sheets 1a to 1e. Since it is directly fixable to a substrate 3, it is easy to put the bearing board 11 in practical use from drawing 2 and the example of 3.
[0017] Drawing 9 is the example which installed the squeeze pneumatic-bearing boards 11a and 11b in two sheets, best disk 1a and lowest disk 1e. In this case, the damping effect over the flutter in the locking imbalanced mode can be raised to the double precision of the example of drawing 8 .
[0018] On the other hand, when vibration of the balance mode in which the couple of each disk side of a disk spindle vibrates symmetrically also causes a truck gap, as shown in drawing 10 , the composition of making 1e countering from disk side 1a of it that, and installing 11e in one one side side of each disk side from squeeze bearing board 11a becomes important. As for a bearing board, not thickening superfluously is desirable thickly to the grade which does not excite vibration itself according to the disturbance force of air here. Although the thickness which can recommend a bearing board changes also with sizes of width of face, what is necessary is just usually about 1mm. Moreover, it is desirable to make the edge of a bearing board into the stream-line configuration 19 so that a bearing board may not disturb the flow of the air between disk boards. Although the radial free edge of a bearing board is shown by the stream line in this drawing, the first transition and the trailing edge to a flow of a circumferencial direction in a disk also serve as a stream-line configuration similarly. In addition, although the bearing board is installed in the disk upper surface in drawing 10 , of course, you may install in the undersurface of a disk.
[0019] As the example of beyond [effect] some with a new this invention described, this invention is characterized by to carry out [in a disk side] the installation fixation of the bearing board with the fixed degree field of angle of circumference, and the smooth field of the shape of a subring with radial width of face mostly in a crevice 0.3mm or less at parallel, and has the effect which damps a disk flutter notably by the damping effect of a squeeze air film.

[Translation done.]

TECHNICAL FIELD

A [technical field to which invention belongs] this invention relates to the equipment which damps disk flutter vibration by which air excitation is carried out with a raise in the rotational speed of magnetic disk memory or an optical disk memory.

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PRIOR ART

As for [Prior-art] magnetic disk memory, densification and high-speed-ization are always demanded. Especially disk rotational speed exceeds 10000rpm, and the magnetic disk unit for high-end will require the more and more high recording density-ization under the further high rotational-speed conditions from now on. Although to improve especially track density is demanded strongly, vibration of the disk which an eddy is formed in the airstream between disk boards, or the air of the disk circumference is confused, excites the natural frequency of a disk along with increase of disk rotational speed, and is called disk flutter arises, and this causes a truck gap. Although there are various kinds in vibration of a disk spindle, the locking imbalanced mode in which a disk and a shaft incline and vibrate by the inphase or the antiphase also especially in it serves as a key factor of a truck gap. There is also nonrotation synchronous vibration produced from anti-friction bearing among the vibration of the disk leading to a truck gap. Although the liquid bearing is going to be used in order to remove this, if the disk flutter excited in aerodynamic force is not oppressed even if a liquid bearing is used, the advantage of a liquid bearing cannot be employed efficiently. For this reason, it was a big technical problem for damping and removing a disk flutter developing a highly efficient magnetic disk unit in recent years.
[0003] In order to remove the eddy of the air between disk sides and to abolish disorder of the air of the disk periphery circumference as this solution, a hole is made in the spacer ring of the clamp mechanism of the center of a disk, and the structure of making air blowing off from a center section using the centrifugal force of air at the time of rotation is proposed. Moreover, the structure which sealing covering of the disk circumference is made to approach the disk side, and prevents a turbulent flow was proposed. Furthermore, in order to prevent the eddy of the shape of a cell produced between disk boards, and the flutter of the head suspension by this, the method of inserting the partial board called spoiler locally between disk layers is also proposed. However, these were for preventing generating of the turbulent flow and vortex which do not oppress vibration of the De Dis board by attenuation, but are produced between disk layers. Moreover, these methods did not not necessarily have the effect which can oppress a flutter over a large frequency domain. Although the proposal which uses the large disk board made from a ceramic of attenuation was also proposed on the other hand, it became expensive, and change of IE was also required and its demerit was large.
[0004] On the other hand, as shown in drawing 1 , I.Y.Shen and others approaches the best side of a disk spindle, carries out a support setup of the annular disk 6 through the viscoelasticity material 8 from the arm top cover 7 of equipment, and has proposed the flutter damping mechanism which absorbs the vibrational energy of a disk spindle using the principle of a dynamic vibration reducer in recent years. The crevice between an annular disk and the disk best side forms dynamic pressure pneumatic bearing, and is made to be transmitted to the mass which aligned vibration of a disk spindle using the spring effect by the compressibility of air by about 0.635mm. Although it is shown that the attenuation to which it damps produces the annular disk disk flutter which they approached, the dynamic-vibration-reducer structure of drawing 1 is proposed only now noting that there are few effects. Since a squeeze damping effect is seldom produced when the crevice between the smooth sides which counter a disk side is too large like [in this case] and a disk vibration amplitude is 1 or less % of a crevice, the exciting force of disk vibration is transmitted to an annular disk using the spring effect produced as a hydrodynamic bearing, and the method of attenuating the vibration by viscoelasticity material becomes effective. By this dynamic-vibration-reducer form damping mechanism, attenuation of the flutter of a disk is the relation which absorbs an annular disk by the viscoelasticity material which supports about vibration transmitted to the annular disk instead of an air film between an annular disk and a disk. However, an alignment design and the design of the damping effect of support attenuation material were not easy for this kind of damping mechanism, and it had the fault which moreover becomes complicated [a mechanism].

[Translation done.]

EFFECT OF THE INVENTION

As the example of beyond [effect] some with a new this invention described, this invention is characterized by to carry out [in a disk side] the installation fixation of the bearing board with the fixed degree field of angle of circumference, and the smooth field of the shape of a subring with radial width of face mostly in a crevice 0.3mm or less at parallel, and has the effect which damps a disk flutter notably by the damping effect of a squeeze air film.

[Translation done.]

TECHNICAL PROBLEM

A [Object of the Invention] this invention is damping the disk flutter produced by the exciting force of the air acting as high-speed-izing of a magnetic disk, and the greatest obstacle of a raise in track density as mentioned above. it is not based on the principle using the means which makes the size of the disturbance force of conventional air small especially or the spring effect of pneumatic bearing, and the damping force of external-damping material of a dynamic vibration reducer, but vibration of a flutter is damped by the easier means -- they are things

[Translation done.]

MEANS

The subring-like side field which spread in radial and the circumferencial direction of one side of a disk side is made to approach a disk side enough, and the disk flutter damping device of a [The-means-for-solving-a-technical-problem] this invention installs a smooth fixed wall surface almost parallel to a disk side in it, is characterized by making the damping effect based on a squeeze pneumatic-bearing principle form in the crevice between a disk side and a stationary-plate side, and explains it in detail using a drawing below.
[0007] [Gestalt of implementation of invention] drawing 2 and drawing 3 are drawings showing the fundamental operation gestalt of this invention. A view 2 is a cross section of basic structure, and, for a disk and 2, as for a substrate and 4, a main fixed shaft and 3 are [1 / a motor and 5] anti-friction bearings. The squeeze pneumatic-bearing board with which 11 makes the center of this invention, and 12 are the crevices between a disk board and a squeeze pneumatic-bearing board. Moreover, the spacer ring for ****ing and 14 fixing two or more disk boards in a fixed crevice with which 10 combines upper surface covering and 13 combines upper surface covering and a main fixed shaft, and 15 are side cases, and are being fixed to the substrate 3. Drawing 3 is the external view showing the feature of the configuration of the squeeze bearing board of drawing 2 , and is drawing which omitted the upper surface covering 10, a substrate 3, the side case 15, etc. of drawing 2 . 16 is the record reproducing head and 17 is a head positioning mechanism.
[0008] The 1st feature of the squeeze pneumatic-bearing board 11 is that the field which counters a disk side is processed flat and smooth, and is being mostly fixed to parallel by the side case 15 of a disk unit by the periphery with the disk side. The 2nd feature has enough the small crevice 12 between the squeeze pneumatic-bearing board 11 and the best side of a disk 1, and it is specifically about 0.3mm or less. especially this point is an important point of producing a different effect from the conventional technology shown in drawing 1 , and the squeeze damping force of the air film which acts on a disk side makes it sufficient size for making a flutter damp by making it small in this way -- things are made The 3rd feature of the squeeze pneumatic-bearing board 11 is that the bearing surface which forms a small crevice covers not the whole disk side but a part of disk side. Although this covering field changes by other design conditions of a disk unit, in the case of a 3.5 inch disk, usually, the range of it is theta= 60 degrees - 270 degrees, and it is [a circumferencial direction] in radial from a periphery side at the range of lx=10mm to 20mm. As for the radial length, generally depending on the path of a disk, about [of an effective radius / 1/2 or less] is desirable. This range is because the rate of increase of a damping effect decreases by the inner circumference side since a flutter amplitude also becomes small, even if it enlarges not much at a radial inner circumference side, although the larger one has a large effect.
[0009] With the squeeze pneumatic-bearing board 11 with the physical relationship of the above configurations and a disk side, by vibration of a disk, the air in a crevice goes in and out from a crevice by vibration of a disk, and the viscous-drag force which is proportional to the velocity of vibration of a disk according to the viscosity of air acts on a disk. flutter vibration which has a component from 500Hz to severalKHz although this viscous-drag force has the frequency characteristic -- or less at least 1 / 2 -- decreasing -- the crevice between a bearing board and a disk board -- sufficient thing made small is important Although the crevice for acquiring this effective damping effect may be so large that a bearing surface product is large, in the case of the diameter disk of 3.5 inch, you have to make it at least 0.3mm or less, for example. Moreover, it is necessary to make it still smaller as a bearing surface product becomes small. The fundamental damping effect of the squeeze pneumatic-bearing board obtained by an experiment and analysis below is explained in detail.
[0010] Drawing 4 is as a result of [of the frequency spectrum of the case where there is no stationary plate, and the disk vibration when attaching a squeeze pneumatic-bearing board] measurement, when rotating the disk of one sheet by 9600rpm. Although vibration of a disk is the result of measuring near the lower stream of a river of a squeeze pneumatic-bearing board, its near upstream of a bearing board is also almost equal. The squeeze pneumatic-bearing board is installed so that a minute crevice parallel to a disk side may be maintained in the range with a radial width-of-face lx=15mm and an angle [of a circumferencial direction] of theta= 90 degrees, and it is the experimental result of the flutter damping effect when changing the crevice between bearing boards in h= 50-100 micrometers. The peak of the spectrum in this drawing consists of a thing of the integral multiple of rotational speed, and the other component. Although an amplitude does not change with these squeeze pneumatic-bearing boards since the former is based on the wave of a disk side, it does not become the cause of a truck gap. Only the latter is the disk oscillating component which is the disk flutter excited at random and serves as a key factor of a truck gap with air. Although the various natural frequencies of a disk are excited by the disturbance force of an airstream in the 0.5kHz - 2.5kHz field when there is no squeeze pneumatic-bearing board 11 as shown in this drawing, in the case of h= 50 micrometers of crevices, all flutter components are damped nearly completely. Although the damping effect will become weaker if it becomes about h= 100 micrometers of crevices, if an about 500Hz component with the smallest frequency is removed, the vibration amplitude will be reduced to 10 by about 1/. It is clear from these drawings that the disk flutter damping device's using the squeeze pneumatic-bearing effect of this invention there is a remarkable effect. As for vibration of the disk which attached this damping device, it is most effective that avoid the head positioning mechanism 17 near the squeeze pneumatic-bearing board 11, and it installs in the position near the record reproducing head 16 as shown in drawing 3 on the occasion of application to an actual disk unit since vibration is oppressed most. However, what is necessary is for other design conditions just to determine the installation of a bearing board, since the disk flutter of the angular position which is most separated from the squeeze pneumatic-bearing board 11 is also damped enough, considering the property of the oscillation mode.
[0011] Drawing 5 (a) and drawing 5 (b) consider the length of a bearing board as theta= 90 degrees with the angle of circumference, and are the theoretical analysis result of squeeze damping-force F/alpha=Cs omega [in / the rectangle squeeze

bearing in lx=15mm and 10mm / for the width of face] per unit width of face (for a disk vibration amplitude and Cs, a damping coefficient and omega are / F / a damping force and alpha / angular frequency). A parameter is the crevice h between squeeze air film thickness, i.e., a disk side, and a bearing board. It is the frequency domain which becomes fixed [the field where damping-force Csomega increases-like proportionally in frequency / a damping coefficient], and an air film mainly becomes dominant [a damping force] at this time. However, in the field in which a crevice becomes small and frequency becomes high like [in h= 40-50 micrometers of drawing 5 (a)], a damping force is saturated, and for the compressibility of air, the damping effect of an air film decreases and becomes dominant [the effect of a spring] instead. It is characterized by this invention using the field where a damping force is proportional to frequency, and therefore, even if a disk, a bearing board, and a crevice are too small not much, an effect cannot be demonstrated. About h= 40 micrometers of crevices are the the best for reducing disk flutter vibration of several kHz or less from this drawing in the case of lx=15mm. If width of face becomes large, the crevice where this damping effect serves as the maximum will be made greatly-like proportionally. If it is difficult to set a crevice to 50 micrometers or less from the relation of assembly ****** in fact and a crevice is made small, driving torque will become large for the viscous force of an air film. According to the experiment using the veneer disk, the amount of increases of the current of the drive motor when setting up lx=15mm and a theta= 180-degree bearing board with the largest area in 40 micrometers of crevices was about 10%. However, in an actual magnetic disk unit, since it is surrounded by covering and the side attachment wall, it is expected that increase of driving torque with a bearing board becomes larger. Therefore, on the occasion of utilization, a crevice is determined in consideration of the trade-off with the damping effect of flutter vibration, and driving torque increase, and assembly precision.
[0012] In order to make a damping effect into the maximum under the area fixed condition of a squeeze pneumatic-bearing board, about any [the width of face lx of the bearing surface, and] of the angle of circumference theta should be made large, it can guess from drawing 5 (a) and 5 (b). If the frequency of vibration observes by 2kHz in these drawings in the case of h= 50 micrometers of crevices, damping-force F/alpha=Cs omega per unit amplitude is m in it it F/alpha =3N/m and 1N /at the time of lx=15mm and 10mm. That is, the damping force is 3 times if width of face of the bearing surface is enlarged 1.5 times. In the case of a band-like squeeze pneumatic-bearing side, this reason is that a damping force is proportional to the product of squeeze number sigma=12microomegalx2/h2 (mu is a viscosity coefficient of air) and bearing surface product lxtheta. That is, a damping force is proportional to the cube of the bearing width of face lx, and proportional to the angle of circumference theta. Therefore, in order to heighten the damping effect of a disk flutter, it is effective rather than the direction which enlarged width of face lx with the narrower bearing surface enlarges angle of circumference length theta. However, since the amplitude of flutter vibration of a disk becomes small in the field where a radius position is small, even if it enlarges width of face lx from the periphery of the bearing surface not much, increase of the damping effect cannot be desired. The suitable bearing width of face lx will be to about 20mm, since the inradius which fixes a disk in the case of a 3.5 inch disk unit is about 15mm and an effective disk side radius is about 30mm. general -- fixation of a disk -- about [of the effective radius of a hub to an outside] 1/2 is suitable
[0013] the component with high frequency of the experimental result of drawing 4 to the flutter damping effect is larger, and the circumference component of back which is the minimum primary locking imbalance mode this [whose] it is the mode of the about 0.5kHz node circle 0 of the following frequency and the node diameter 1, and is one of the factors of a truck gap has the smallest damping effect then, the minimum which is the hardest to be damped -- drawing 6 showed the ratio (amplitude reduction ratio) with an amplitude in case there is no squeeze pneumatic-bearing board of a vibration amplitude in case there is a bearing board about lx=10mm, 15mm, and the angle of circumference in bearing width of face about four kinds of squeeze pneumatic-bearing boards (theta= 90 degrees and 180 degrees) which it changed at a time two levels, respectively paying attention to the following flutter oscillating component as a function of a crevice Drawing 6 is the case where rotational speed is 9600rpm, and each parameter is the difference in the size of the bearing surface. I am doing as the property of the damping effect which the damping effect is [to increase width of face lx 1.5 times] larger, and this showed by drawing 5 (a) and 5 (b) one rather than that these drawings show makes the angle of circumference theta double precision although the damping effect generally has the large one where a bearing surface product is larger especially Also in h= 100 micrometers of crevices, at lx=15mm and theta= 180 degrees, the flutter is reduced to one fifth by about 1/10, lx=10mm, and at least theta= 90 degrees, and the remarkable damping effect of the squeeze pneumatic-bearing board of this invention is clear from this drawing. if the crevice between a disk and a bearing plate surface is enlarged -- the damping effect -- a crevice -- almost -- in inverse proportion -- decreasing -- **** -- therefore -- a crevice -- about h= 0.2mm -- even when -- a flutter vibration amplitude can be damped about to 1/5 by choosing a bearing surface product comparatively greatly Although not shown in this drawing, in the case of lx=15mm with the largest area used for the experiment, and the theta= 180-degree bearing board, the amplitude reduction ratio was 0.78 at the time of 0.58 and h= 0.37mm at the time of h= 0.3mm. For making a flutter vibration amplitude small [to one half] at least after this, even when a bearing surface product is comparatively large, a crevice needs to set to 0.3mm or less, and if driving torque conditions allow, generally it will be thought that the range of bearing clearance of 0.1mm - 0.2mm is desirable.
[0014] Disk flutter vibration damps and a different new effect from the former uses by the disk flutter damping device which was described above and which consists of a squeeze pneumatic-bearing board of this invention like easing disorder of the air between disk boards like the conventional stabilizer, not reducing exciting force, and not depending it on a dynamic vibration reducer, either, and making a disk side carry out direct action of the damping force of a squeeze air film. Thickness h of the air film of drawing 6 to squeeze pneumatic bearing needs to be 0.3mm or less to acquire the damping effect from which a flutter amplitude becomes 1/2 or less. Moreover, if the crevice of the size of a squeeze pneumatic-bearing side is 0.1mm and width of face has about 60 degrees or more of angle of circumferences again that there should just be 10mm or more from a periphery side, as for an amplitude reduction ratio, 1/3 or less will be obtained. on the other hand, since the bearing surface is also made not much large to radial and the rate of increase of the effect decreases, the width of face of the bearing surface has the range suitable for the angle of circumference of 90 to 180 degrees at about [of the effective radius of a disk] 1/2 However, in order that these values might decrease flutter vibration enough, the recommended value of the subring-like bearing surface size for producing a damping force was only shown, and this invention specifies neither a strict bearing surface configuration nor its fine size. For example, the structure shown in drawing 7 is not a strict subring-like side, and a part of edge by the side of the inradius of the upstream of a squeeze pneumatic-bearing board or a downstream is removed, and it forms the smooth inclined plane 18 so that the airstream caused with a disk may not be disturbed. Even in this case, it is necessary to set a crevice to 0.3mm or less as conditions for generating a squeeze damping effect effectively.
[0015] Although the disk flutter damping device using the damping effect of drawing 2 and the squeeze pneumatic-bearing board shown in 3 and 7 is an example in case there are two disk boards, one sheet or at least three disk boards or more can apply it. The flutter which generally serves as a key factor of a truck gap is the oscillation mode to which the shank of all the disk boards called locking imbalanced mode and center sections exercises for an inphase or an antiphase, and this vibration can be damped

by making a damping force act on the topmost disk of one sheet.

[Translation done.]

EXAMPLE

The flutter damping device of a [example of invention] this invention can consider some of other examples. Drawing 8 is the case where the squeeze pneumatic-bearing board 11 is installed only in the undersurface of disk 1e of the bottom of disk of two or more sheets 1a to 1e. Since it is directly fixable to a substrate 3, it is easy to put the bearing board 11 in practical use from drawing 2 and the example of 3.
[0017] Drawing 9 is the example which installed the squeeze pneumatic-bearing boards 11a and 11b in two sheets, best disk 1a and lowest disk 1e. In this case, the damping effect over the flutter in the locking imbalanced mode can be raised to the double precision of the example of drawing 8 .
[0018] On the other hand, when vibration of the balance mode in which the couple of each disk side of a disk spindle vibrates symmetrically also causes a truck gap, as shown in drawing 10 , the composition of making 1e countering from disk side 1a of it that, and installing 11e in one one side side of each disk side from squeeze bearing board 11a becomes important. As for a bearing board, not thickening superfluously is desirable thickly to the grade which does not excite vibration itself according to the disturbance force of air here. Although the thickness which can recommend a bearing board changes also with sizes of width of face, what is necessary is just usually about 1mm. Moreover, it is desirable to make the edge of a bearing board into the stream-line configuration 19 so that a bearing board may not disturb the flow of the air between disk boards. Although the radial margo liber of a bearing board is shown by the stream line in this drawing, the first transition and the trailing edge to a flow of a circumferencial direction in a disk also serve as a stream-line configuration similarly. In addition, although the bearing board is installed in the disk upper surface in drawing 10 , of course, you may install in the inferior surface of tongue of a disk.

[Translation done.]

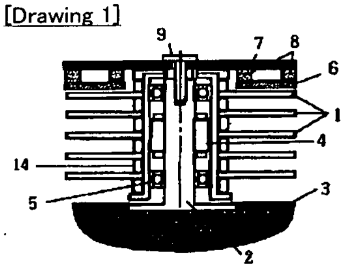
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the cross section showing the example of representation of the conventional flutter damping device.
[Drawing 2] It is the cross section showing the basic structure of the flutter damping device of this invention.
[Drawing 3] The external view which removed covering, substrate, and side plate of drawing 2
[Drawing 4] The experimental data which shows the flutter damping effect of the squeeze bearing board of this invention
[Drawing 5] The frequency characteristic of the squeeze damping force by the rectangle squeeze bearing theory
[Drawing 6] The experimental value of the flutter damping effect by various kinds of squeeze pneumatic bearing
[Drawing 7] Other examples of a configuration of the squeeze bearing board of the flutter damping device of this invention
[Drawing 8] Other examples of the flutter damping device of this invention
[Drawing 9] Other examples of the flutter damping device of this invention
[Drawing 10] Other examples of the flutter damping device of this invention
[Description of Notations]
1 Disk
2 Main Fixed Shaft
3 Substrate
4 Motor
5 Anti-friction Bearing
6 Annular Disk
7 Arm Top Cover
8 Viscoelasticity Material
9 Lockscrew
10 Upper Surface Covering
11 Squeeze Pneumatic-Bearing Board
12 Crevice
13 Screw Thread
14 Spacer Ring
15 Side Case
16 Record Reproducing Head
17 Head Positioning Mechanism
18 Inclined Plane
19 Stream-Line Configuration

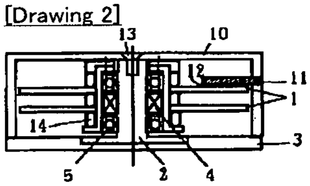
[Translation done.]

DRAWINGS

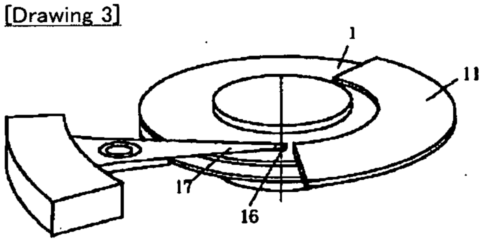
[Drawing 1]



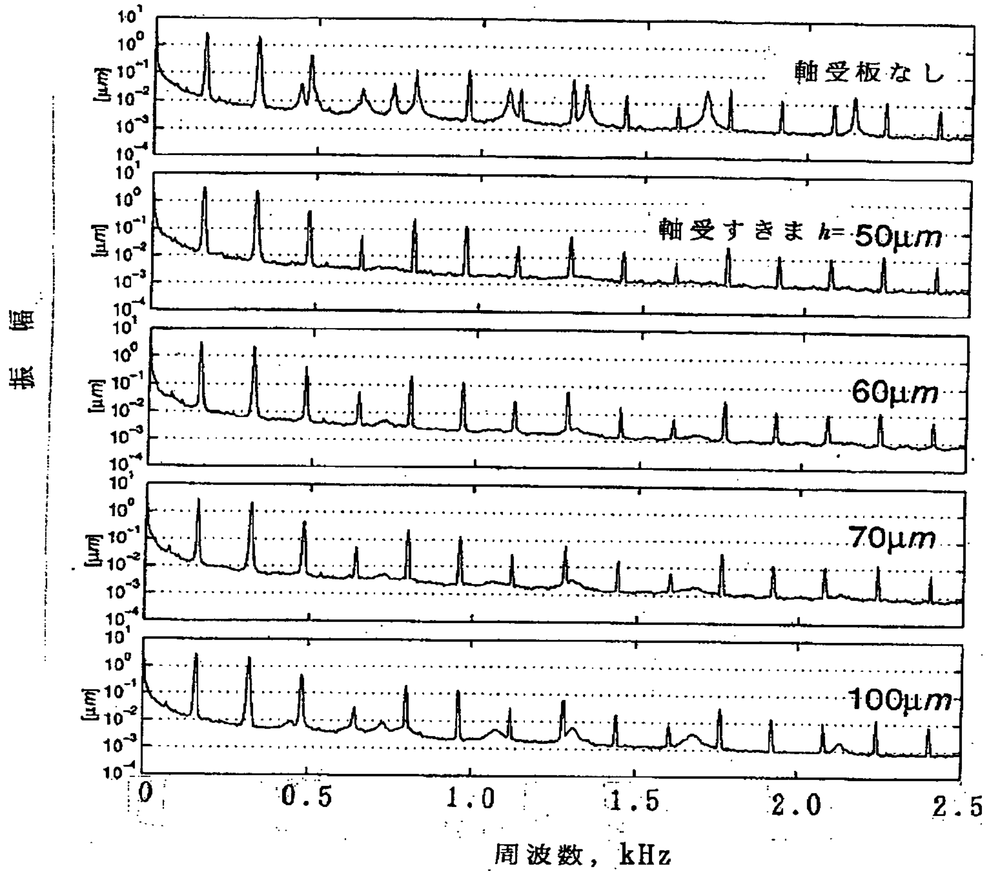
[Drawing 2]



[Drawing 3]

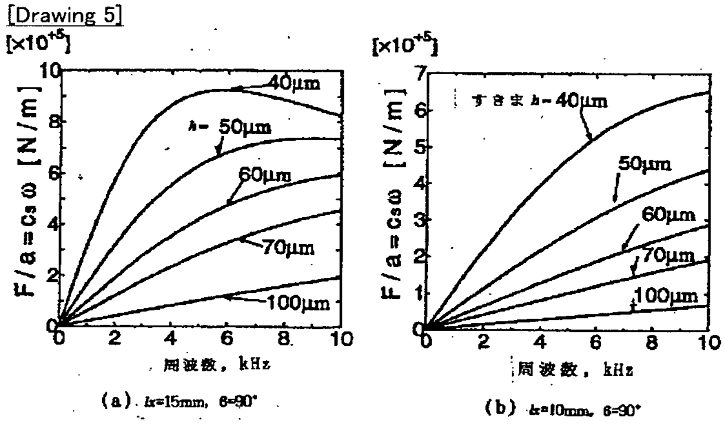


[Drawing 4]



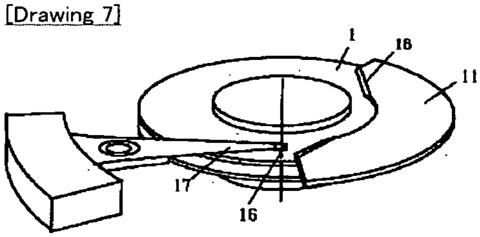
lx=15mm, θ=90° の軸受板のフラッタ制振効果（9600rpm)

[Drawing 5]

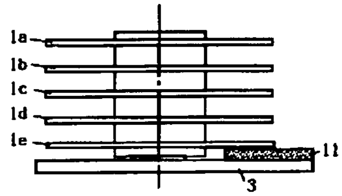


矩形スクイーズ空気軸受の減衰力の周波数特性

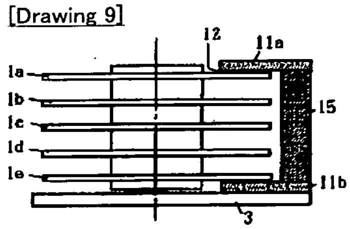
[Drawing 7]



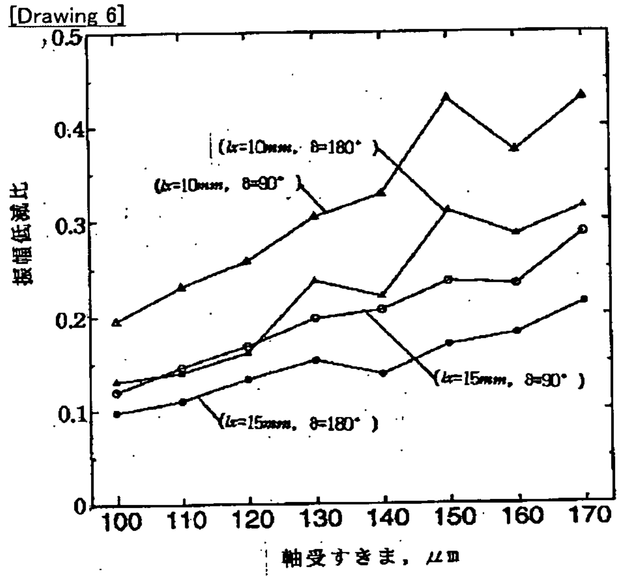
[Drawing 8]



[Drawing 9]

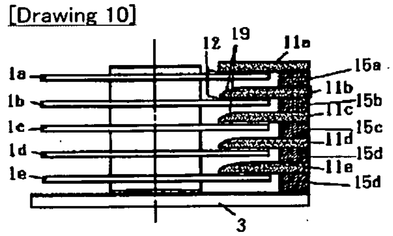


[Drawing 6]



各種軸受板を用いたときの最低次フラッタ振動
成分の振幅低減比と軸受すきま（回転速度:9600rpm）

[Drawing 10]



[Translation done.]